



Research Article

The Effect of Local Agricultural Technologies on Reducing Food Spoilage (Vegetables) in Tubah Subdivision, North-West Region Cameroon

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Abstract

This study examines the effect of local agricultural technologies on reducing vegetable spoilage in Tubah Subdivision, Northwest Cameroon. Using a cross-sectional survey design, the study assesses the adoption of local preservation methods, their relationship with vegetable spoilage, and the challenges limiting their effectiveness. The findings show that sun drying (86%) and traditional barn storage (37%) are the most widely adopted preservation methods, with knowledge primarily acquired through fellow farmers and family traditions. Binary logistic regression results reveal that gender and educational attainment significantly influence food spoilage. Female farmers and farmers with secondary education are more likely to adopt preservation methods that reduce spoilage. Traditional barn storage and the use of ash are positively associated with food spoilage, whereas sun drying and local refrigeration are associated with reduced spoilage. However, farmers and traders face considerable challenges in preserving vegetables, including inadequate awareness and training (71%), limited storage infrastructure (63%), and climate-related constraints (54%). These findings highlight the importance of combining traditional knowledge with technical training and infrastructural support to improve vegetable preservation. The study recommends strengthening agricultural extension services, promoting women's participation in preservation activities, enhancing educational outreach, upgrading storage facilities, and supporting affordable, locally appropriate preservation technologies. Such interventions could improve farmers' capacity to manage post-harvest losses, reduce vegetable spoilage, and enhance food availability and livelihood outcomes in Tubah Subdivision. The study underscores the need for agricultural policies that recognize existing local practices while addressing the knowledge, infrastructure, and environmental constraints affecting their effectiveness.

Keywords

Vegetable Preservation, Local Agricultural Technologies, Food Spoilage, Tubah Subdivision, Post-harvest Management

1. Introduction

Food spoilage remains a significant challenge to global food security, contributing to the loss of nearly one-third of all food produced for human consumption each year, which is

equivalent to approximately 1.3 billion tons [15]. This widespread wastage not only represents a massive inefficiency in the global food system but also has serious implications for

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environmental sustainability, economic development, and social equity. In regions where food availability and affordability are already constrained, food spoilage compounds issues of hunger, malnutrition, and income inequality in low and middle-income countries [29]. The economic loss associated with food spoilage affects multiple stakeholders across the agricultural value chain, from smallholder farmers to distributors and retailers, creating barriers to economic empowerment and sustainable livelihoods [23]. Reducing food loss is therefore not just an agricultural concern but a multidimensional issue tied to health, climate change, and poverty alleviation.

To address this global problem, various agricultural technologies and innovations have been introduced to mitigate food spoilage, particularly during post-harvest stages. Techniques such as improved sorting and grading, cold chain development, vacuum-sealed packaging, and the use of climate-smart storage facilities have demonstrated considerable success in extending the shelf life of perishable commodities and improving supply chain efficiency [21]. In industrialized nations, these advancements are often supported by robust infrastructure, access to financing, and government policies that promote research and development [61]. However, in low-income and rural areas, particularly in sub-Saharan Africa and parts of South Asia, the adoption of such technologies remains patchy and slows [2]. Structural limitations such as inadequate rural electrification, poor road networks, lack of technical support services, and low digital literacy often hinder the effective diffusion of innovation among small-scale farmers and cooperatives.

In Africa, food spoilage constitutes a critical bottleneck in achieving food security goals. It is estimated that approximately 40% of food produced on the continent is lost before reaching the consumer, with post-harvest losses accounting for the bulk of this figure [20]. The loss is particularly pronounced in perishable crops such as fruits, vegetables, dairy, and fish, which are highly sensitive to temperature and handling conditions [8]. The root causes of these losses include a lack of cold storage infrastructure, inefficient logistics, minimal use of preservatives, and poorly coordinated markets [25]. In response, several African nations have started piloting and investing in promising technologies and community-driven solutions [31]. Examples include solar-powered cold rooms, hermetic storage bags, biodegradable packaging, and mobile apps that link farmers to markets in real time. These interventions hold potential, yet they remain limited in scale due to financial constraints, insufficient policy incentives, and low levels of awareness among end-users [55]. Moreover, many of these innovations lack contextual tailoring to address the unique agroecological and socio-economic dynamics of different regions [43].

In Cameroon, where agriculture employs over 70% of the population and contributes significantly to gross domestic product (GDP), food spoilage is a persistent and multifaceted issue that undermines both productivity and food availability

[1, 45]. Smallholder farmers, who constitute the majority of the agricultural workforce, often lack access to proper post-harvest handling practices, storage infrastructure, and market information [14]. As a result, crops such as tomatoes, plantains, yams, and cassava frequently rot before they can be sold or consumed. Studies indicate that post-harvest losses for perishable crops in Cameroon range between 25% and 30% annually [38], representing a substantial economic burden for rural communities. Over the years, the Cameroonian government has launched various initiatives, such as agricultural extension programs, training workshops, and public-private partnerships aimed at modernizing agriculture. However, the impact of these efforts has been limited by fragmented implementation, inconsistent funding, weak monitoring and evaluation frameworks, and resistance to adopting unfamiliar practices.

Tubah Subdivision, situated in the North-West Region of Cameroon, offers a localized example of how food spoilage hampers rural development. With a predominantly agrarian economy, the majority of households depend on subsistence and small-scale commercial farming for their livelihood. Crops such as vegetables, Irish potatoes, beans, and cocoyams dominate agricultural production, yet a large proportion of the harvest is lost post-harvest due to reliance on rudimentary storage and transportation methods [28]. Farmers in Tubah often transport produce on poorly maintained roads using non-specialized vehicles, which exacerbates spoilage [30]. Additionally, they lack access to refrigeration, drying facilities, and market intelligence, all of which are crucial for reducing loss and enhancing income. In recent years, local non-governmental organization (NGOs), researchers, and community-based organizations have introduced affordable technologies, such as solar dryers for preserving leafy greens, evaporative cooling systems, and digital platforms that connect producers to urban markets [59]. These interventions, although promising, are often met with challenges including limited funding, poor maintenance, and insufficient training on usage and upkeep. [41].

Studying the effectiveness of such innovations in Tubah can yield valuable insights into the viability of low-cost, scalable solutions for food spoilage across similar rural contexts. By understanding the socio-cultural, economic, and environmental factors that affect technology adoption, development practitioners and policymakers can design more inclusive and sustainable interventions. Ultimately, addressing food spoilage at the grassroots level not only improves food security and farmer income but also contributes to national efforts to reduce poverty, stabilize food prices, and meet international development goals such as the Sustainable Development Goals (SDG 2 (Zero Hunger)) and the Cameroon's National Development Strategy 2020-2030 (SND30) of accelerating agricultural development within the national territory. These strategies present practical information for industry stakeholders and policymakers.

1.1. Problem Statement

Food spoilage is a critical issue in many developing regions, including Tubah Subdivision in the North-West Region of Cameroon, where agriculture serves as the backbone of livelihoods, household income, and the local economy [30]. According to [16], it is estimated that approximately one-third (that is, 1.3 billion tons) of all food produced for human consumption is lost or wasted annually. In Sub-Saharan Africa, post-harvest losses account for up to 37% of total food production, largely due to, insufficient storage facilities, inadequate harvesting techniques, limited processing capacity and poor transportation [3]. These challenges are particularly pronounced in Tubah Subdivision, where smallholder farmers rely heavily on traditional methods, face persistent infrastructure deficits, and have limited access to competitive markets [30].

In response to these challenges, the introduction of agricultural technologies such as improved granaries, solar dryers, mobile-based market platforms, and low-cost processing tools has been widely promoted as a means to reduce post-harvest losses and improve food availability [33]. Local agricultural innovations tailored to the specific agro-ecological and economic conditions of rural communities have shown potential in mitigating food spoilage [32]. These include indigenous drying techniques, the use of natural preservatives, and community-shared storage systems. However, the effectiveness of these solutions in Tubah Subdivision remains questionable, as food spoilage continues to undermine food security and farmer productivity. Several constraints hamper the broader adoption of these technologies, including high initial investment costs, limited awareness of available innovations, inadequate training and extension services, and cultural resistance to change [20].

Understanding the extent to which both modern and local agricultural technologies can effectively address food spoilage in Tubah Subdivision is therefore crucial. It is not only key to enhancing food security and stabilizing local food supply chains, but also to improving farmer incomes and reducing the environmental impact associated with wasted food. This study aims to fill a critical knowledge gap by investigating the relationship between agricultural technology adoption and food spoilage reduction in Tubah. It will also explore the underlying challenges that impede effective technology uptake and propose context-specific strategies to improve the resilience and efficiency of the local agricultural system.

1.2. Research Objectives

The main research objective of this research is to analyze the effect of local agricultural technologies on reducing food spoilage (vegetables) in Tubah Subdivision. Specifically, the research seeks to achieve the following key objectives: 1) To identify the local agricultural technologies used in mitigating food spoilage (vegetables) in Tubah subdivision. 2) To assess how these local agricultural technologies have contributed to

reducing food spoilage (vegetables) in the supply chain within Tubah subdivision. 3) To analyze the challenges associated with implementing local agricultural technologies for food preservation in Tubah subdivision.

2. Literature Review

2.1. Conceptual Literature

2.1.1. Agricultural Technologies

Agricultural technologies refer to the tools, machinery, techniques, and innovations aimed at improving productivity, efficiency, and sustainability in agriculture [44]. These technologies encompass modern farming practices such as mechanization, irrigation systems, post-harvest storage facilities, and digital platforms for farm management [16]. Various authors provide insights into the role and nature of agricultural technologies: Elis [13] defines agricultural technologies as a combination of physical tools and improved farming methods designed to increase the productivity of land and labor while ensuring sustainability. Pretty [52] highlight that agricultural technologies incorporate practices such as precision farming, genetically modified organisms (GMOs), and integrated pest management systems, which aim to optimize resource use and reduce environmental impact. While Pingali [50] categorizes agricultural technologies into labor-saving and land-saving technologies, stressing that both types have implications for reducing post-harvest losses, especially in developing countries.

The adoption of advanced agricultural technologies has potential implications for reducing food spoilage. Technologies such as:

- 1) Improved irrigation systems and soil management practices can enhance crop yields and minimize post-harvest defects.
- 2) Innovations like hermetic storage bags and solar drying techniques can significantly reduce moisture-related spoilage.
- 3) The use of mobile apps and Internet of Things (IoT) devices can help farmers monitor environmental conditions, predict spoilage risks, and implement timely interventions.

2.1.2. Food Spoilage

Food spoilage refers to the process by which food becomes unfit for human consumption due to physical, chemical, or microbial changes. The concept has been explored by numerous researchers: Jay [24] describes food spoilage as the deterioration of food quality due to microbial growth, which leads to changes in texture, odor, and appearance, rendering it unpalatable or unsafe. Frazier and Westhoff [18] point out that spoilage can occur due to enzymatic activity, oxidation, or mi-

crobial contamination, emphasizing that poor storage conditions often exacerbate these processes. In this regard, Gram [19] underscores the importance of refrigeration in controlling spoilage, noting that a lack of proper cooling systems in tropical regions significantly increases food wastage. This is consistent with the broader evidence that inadequate handling, storage and post-harvest conditions contribute significantly to food losses, particularly for highly perishable products such as fruits and vegetables [16].

2.2. Theoretical Literature Review

2.2.1. Innovation Diffusion Theory

The Innovation Diffusion Theory, developed by Rogers [53], explains how new technologies or ideas spread through a social system over time. The theory states that the adoption of innovations follows a predictable process consisting of five stages: knowledge, persuasion, decision, implementation, and confirmation. It assumes that individuals differ in their readiness to adopt new practices and that adoption occurs in categories innovators, early adopters, early majority, late majority, and laggards depending on social influence and perceived benefits. The theory further assumes that communication channels, perceived relative advantage, compatibility with local norms, and observability of results significantly shape adoption outcomes [54]. For instance, when solar dryers or improved vegetable storage bins are introduced in rural communities, early adopters influence their peers through demonstration and trust networks. However, critics argue that the theory tends to overlook structural barriers such as credit access, gender inequality, and institutional support, focusing excessively on individual decision-making [27]. Despite these limitations, the theory is relevant to this study because it helps explain how and why local farmers in Tubah decide to adopt or reject agricultural technologies aimed at reducing vegetable spoilage, and how communication networks and perceived benefits affect their willingness to sustain these practices.

2.2.2. Sustainable Livelihoods Framework (SLF)

The Sustainable Livelihoods Framework (SLF), proposed by Chambers and Conway [11], provides a holistic approach to understanding how households use available resources to build sustainable living conditions. The framework posits that livelihood sustainability depends on the interaction between five forms of capital human, natural, financial, physical, and social and the vulnerability context that influences access to these assets. It assumes that improving access to these capitals enhances people's capacity to cope with shocks, adapt to

changes, and pursue sustainable livelihood strategies. For example, when farmers have sufficient physical capital such as storage facilities or financial capital to maintain solar dryers, they are less vulnerable to post-harvest losses. However, the SLF has been criticized for being descriptive rather than predictive, and for underemphasizing power relations and institutional constraints that shape resource access [57]. Nonetheless, in the context of Tubah Subdivision, this framework is essential because it situates the adoption of local agricultural technologies within broader livelihood systems. It helps explain how farmers' resource constraints, social networks, and institutional environments affect their ability to adopt technologies that minimize vegetable spoilage and improve income stability.

2.2.3. Post-Harvest Loss Theory

The Post-Harvest Loss Theory, articulated by Kitinoja and Kader [34, 37], focuses on identifying where, how, and why food losses occur along the agricultural value chain. The theory states that, losses in perishable crops arise from inefficiencies at multiple stages harvesting, handling, storage, transportation, and marketing each presenting unique risks that require targeted interventions. It assumes that technological, behavioral, and managerial innovations can minimize these inefficiencies and improve food quality and availability. For instance, the adoption of improved harvesting tools, cold storage, and packaging materials has been shown to significantly reduce post-harvest losses in fruits and vegetables [4]. Despite its usefulness, the theory has limitations, as it often focuses on technical fixes without fully considering socio-economic and institutional factors that hinder implementation in low-income contexts. Nevertheless, this theory directly supports the present study by providing a framework for analyzing how local agricultural technologies such as solar dryers, evaporative cooling chambers, and community granaries can address specific points of loss in the vegetable value chain in Tubah Subdivision, thereby reducing food spoilage and improving food security.

2.3. Empirical Literature

Several empirical studies have explored the role of local agricultural technologies in reducing food spoilage, especially in low-resource settings similar to Tubah Subdivision. Table 1, shows how these technologies ranging from indigenous knowledge systems to locally adapted innovations have led to measurable success in preserving perishable crops like vegetables.

Table 1. A synthesis of research outcomes on local agricultural technologies, its impact and barriers toward mitigating food waste.

Author(s) and Publication Year	Study country	Key objectives	Key findings and outcomes	Technological interventions aimed at mitigating food waste
Identify the local agricultural technologies used in mitigating food spoilage				
Ibeanu [22]	Nigeria	Explored local/traditional technology to reduce food spoilage	Emphasize the use of sun drying and smoking, and local storage practices	The study shows that 90% of households use sun-drying, while 87.5% rely on smoking for meat and fish preservation.
Bello [9]	Nigeria	Examined the use of traditional storage barns to reduce food spoilage	Traditional structures such as clay, thatch, or mud contribute to food spoilage due to poor aeration, pest vulnerability, and limited temperature regulation.	Stressed for an upgrade of traditional systems through local innovations
FAO [17]	Sub-Sahara Africa	Examined the use of traditional techniques such as sun drying and fermentation to reduce food spoilage	Sun drying method couple with solar dryers are effective methods used in food preservation	Solar dryers technologies reduce drying time, minimize exposure to environmental contaminants and lead to better quality products with higher market value and reduced post-harvest losses
Mrema and Rolle [42]		Analyze the impact of traditional storage techniques and post-harvest handling practices on food spoilage	This paper argued that the efficacy of traditional storage techniques and post-harvest handling practices can reduce spoilage rate.	Local technologies like improved granaries with wire mesh ventilation or lining storage walls with insect repellent plant materials can reduce food spoilage.
Boateng [10]	Ghana	Explored the use traditional method such as ash and plant-based substances in traditional grain storage	Discussed the potential of ash and plant-based substance in reducing spoilage in traditional grains	Ash and plant-based substances significantly reduce insect infestation
Stathers [58]	East and Southern Africa	Explore the use of ash from burnt crop residues and firewood to prevent spoilage in grains like sorghum and millet.	Implementation of ash varies from different crops residues. The study highlights the important of community-specific trials to account for variation in ash type (wood, plant residue, or dung-based) and storage materials	The study shows a negative relationship between ash use and food spoilage. The use of ash helps maintain grain quality and absorb residual moisture
Kitinoja [35]; WorldVeg,[60] ; Ahmed and Yousif [5]	Sub-Sahara Africa	Reviewed how rudimentary refrigeration can reduce spoilage of perishable items	Implementing such technologies as part of broader post-harvest strategies, particularly where energy infrastructure is limited helps in reducing food spoilage	Rudimentary refrigeration such as evaporative coolers, clay pot refrigerators, cool boxes, cold storage sheds, or underground pits can significantly reduce spoilage of perishable items.
The effect of local agricultural technologies on reducing food spoilage				
Kitinoja and Kader [36]	Sub-Saharan Africa	The research involved field trials in rural farming communities across several countries, were farmers are trained on the use of hermetic bags and compared the effectiveness of these bags	The study introduced hermetic storage bags airtight, reusable bags designed to prevent oxygen from entering and create an environment hostile to pests and fungal growth.	The findings revealed that hermetic bags has the potential to reduce post-harvest losses significantly
Pingali [51]	Developing countries	Investigated the role of genetically modified (GMO) crops in	The findings revealed that pest-resistant GMO crops led to a 30%	The study compared the per-

Author(s) and Publication Year	Study country	Key objectives	Key findings and outcomes	Technological interventions aimed at mitigating food waste
		reducing field-level losses.	reduction in field-level losses caused by pest infestations. In areas prone to heavy pest attacks, such as maize-producing regions in Sub-Saharan Africa, this reduction translated to a significant increase in overall crop yields	formance of genetically modified crops with traditional non-GMO varieties over several growing seasons. Key performance indicators included yield stability, pest damage rates, and input costs.
Zhang [62]	India	Assessed the impact of mechanization on reducing agricultural losses	Mechanized harvesting reduced the time crops remained in the field, minimizing exposure to adverse weather, pest attacks, and spoilage.	The researchers compared farms using mechanized threshers and harvesters with those relying on, manual methods over a three-year period.
Oznur [48]	Turkey	Assessing the impact of technological advancement in reducing food waste.	The study looks how precision agriculture, smart packaging, block chain, artificial intelligence and consumer centric apps can prevent food waste.	The author looks at the potential of developing technologies to induce substantial transformation.
Mehrotra [40]	Global	Investigating the modern technology designed to reduce food-waste throughout the complete meals deliver chain	The findings identify six keys aspects (imprecision agriculture, sensor technologies, predictive analytics, client-oriented technologies, stock tracking, meal making plans, and expiration date reminders, which empower individuals to make knowledgeable selections, lessen household food waste,	The study looks at the role of pre-harvest technology in mitigating food waste. These improvements empower farmers to optimize crop yields, limit losses, and decorate basic production efficiency
Challenges associated with implementing local agricultural technologies for food preservation				
Sanni [56]	Sub-Sahara Africa	Investigate the role of agricultural technology adoption.	The study reveals that small holder farmers lack access to microfinance or loans	Easy access to finance helps farmers to purchase or build these technologies needed in mitigating food waste.
Diarra [12]	Mali	Explored the challenges by farmers to adopt food preservation technologies	Lack of technical knowledge and training were the key indicators limiting the use of preservation technologies.	The study suggested extensive training programs to teach farmers not only how to use the technologies but also how to maintain and repair them
Kitinoja [37]	Developing countries	Explored the challenges of implementing low-cost cooling technologies in rural areas	The research pointed out that climate variability such as high humidity or excessive rainfall poses a significant challenge to technologies like solar dryers or evaporative coolers.	The research emphasized the need for technologies to be adaptable to local climate conditions to increase their effectiveness
Bello [9]	Nigeria	Examined barrier to the adoption of new agricultural technologies.	The study found out that cultural resistance was the main barrier face by farmer to adopt new agricultural technologies.	The study suggested that any successful implementation of new preservation technologies must involve understanding local customs and integrating traditional practices with modern innovations

Author(s) and Publication Year	Study country	Key objectives	Key findings and outcomes	Technological interventions aimed at mitigating food waste
Aker [6]	Niger	Investigate the barriers of using mobile-based market information in mitigating food waste among rural farmers	The author identified inadequate infrastructure, especially poor road networks, as the main challenge in implementing local agricultural technologies. In addition, inadequate access to electricity or cold storage infrastructure limits the widespread adoption of cooling technologies for food preservation.	The lack of reliable transportation infrastructure leads to delays in the distribution of preserved products, which results in spoilage.
Mrema and Rolle [42]	East Africa	Barriers in implementing local preservation technologies	Inadequate cleaning, handling, and sorting practices were identified as the main items limiting farmers to adequately adopt local technologies	This study highlights the importance of integrating post-harvest management training with technological interventions to ensure the preservation process is effective.

Source: Compiled by the Author.

3. Methodology

3.1. Study Area and Source of Data

This study was conducted in Tubah Sub-Division, Mezam Division, of the North-West Region of Cameroon. Tubah is predominantly agricultural, with farming and trading as the major economic activities. The area experiences distinct rainy and dry seasons, and its farmers are key actors in the local vegetable value chain. The Subdivision's unique blend of traditional and modern agricultural practices makes it an ideal setting for understanding the dynamics of technology adoption and its effects on food waste.

The study used primary source of data. This data was collected through structured questionnaires administered to 200 randomly selected farmers and traders. These questionnaires captured information on technology adoption, types of technology used, their contribution to reducing food spoilage, and challenges in implementation.

3.2. Research Design and Sampling Technique

A cross-sectional survey design was adopted for this study, capturing data at a single point in time to describe relationships between variables without any experimental manipulation. This approach allows for a "snapshot" of the current situation regarding the adoption of local agricultural technologies and their effect on food spoilage reduction in Tubah Sub-division. Data collection employed a simple random sampling technique, ensuring that every member of the target population, farmers and traders in the

area, had an equal chance of being selected. This method enhances the representativeness of the sample and minimizes selection bias.

3.3. Model Specification

Given that the dependent variable in this study; reduction of food spoilage is binary (1 = spoilage reduced, 0 = spoilage not reduced), the study employs a binary logistic regression model to examine the relationship between the adoption of local agricultural technologies and food spoilage reduction. Logistic regression is appropriate because it models the probability of an event occurring and estimates the effect of predictor variables on this probability.

The logistic regression model is specified as follows:

$$\log \left(\frac{P(Y=1)}{1-P(Y=1)} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \mu$$

where:

$P(Y=1)$ = probability that food spoilage is reduced;

$\frac{P(Y=1)}{1-P(Y=1)}$ = odds of food spoilage reduction;

X_1 = type of local technology used (categorical: storage = 1, processing = 2, preservation = 3);

X_2 = support available (continuous or categorical as measured in the study);

X_3 = challenges faced in implementing the technology;

β_0 = intercept;

$\beta_1, \beta_2, \beta_3$ = regression coefficients;

μ = error term.

The model estimates the log odds of food spoilage reduc-

tion based on the predictor variables. Coefficients are interpreted in terms of odds ratios to provide meaningful insights into the likelihood of spoilage reduction given changes in the independent variables.

4. Results and Discussion

Table 2 below presents the demographic characteristics of

the respondents. The demographic profile of the 200 respondents in this study shows a predominance of females (57.5%) compared to males (42.5%). Most participants (31%) are aged between 31 and 40 years, followed by those aged 21–30 years (21%), (17%) for age group 41–50 and (15%) for 50+ age groups. Regarding education, 35% have attained secondary education, 22.5% tertiary education, 23% primary education, and 19.5% have no formal education.

Table 2. Demographic characteristics of the Respondents.

		Frequency	Percent
Gender	Male	85	42.5%
	Female	115	57.5%
Age	Below 20	31	15.5%
	21-30 years	42	21%
	31-40years	63	31.5%
	41-50 years	34	17%
	50 and above	30	15%
	No formal education	39	19.5%
	Primary education	46	23%
Level of education	Secondary education	70	35%
	Tertiary education	45	22.5%
	Farmer	102	51%
Occupation	Trader/Market vendor	83	41.5%
	Agricultural Extension officer	10	5%
	Other (specify)	5	2.5%
Level of Income	Less than 25,000FCFA	44	22%
	25,000 -50,000FCFA	49	24.5%
	50,001-100,000FCFA	34	17%
	100,001-150,000FCFA	49	24.5%
	Above 150,000FCFA	24	12%
How long have you been involved in vegetable farming/trading?	Less than 1 year	36	18%
	1 – 5 years	48	24%
	6 – 10 years	71	35.5%
	More than 10 years	45	22.5%

Source: Field survey, 2026 by Author.

Farmers constitute the majority occupational group (51%), followed by traders/market vendors (41.5%), with agricultural extension officers and others representing 5% and 2.5% respectively. In terms of income, 24.5% earn between 25,000–50,000 FCFA monthly, 22% earn less than 25,000 FCFA, and

24.5% earn between 100,001-150,000FCFA monthly. Most respondents (35.5%) have been involved in vegetable farming or trading for 6–10 years, 24% for 1–5 years, 22.5% for more than 10 years, and 18% for less than a year.

4.1. Local Agricultural Technologies for Mitigating Food Spoilage

The findings in Table 3 indicate that sun drying is the most widely recognized method for preserving vegetables, with 86%

of respondents confirming its use, followed by the use of leaves or plant extracts (38%), storage in traditional barns (37%), use of ash (18%), and local refrigeration methods (17%). This suggests a preference for low-cost, traditional methods, likely due to accessibility and cultural familiarity.

Table 3. Local Agricultural Technologies for Mitigating Food Spoilage.

Which local agricultural technologies do you use or know about for preserving vegetables? (Check all that apply)				
	Not selected		Selected	
	Frequency	Percent	Frequency	Percent
Sun drying	14	14%	86	86%
Storage in traditional barns	63	63%	37	37%
Use of ash for preservation	82	82%	18	18%
Use of leaves or plant extracts	62	62%	38	38%
Local refrigeration methods (e.g., underground pits)	83	83%	17	17%
Others (specify)	100	100%	0	0%

How frequently do you use these preservation methods?				
	Not selected		Selected	
	Frequency	Percent	Frequency	Percent
Always	69	69%	31	31%
Sometimes	56	56%	44	44%
Rarely	80	80%	20	20%
Never	95	95%	5	5%

Source: Field survey, 2026 by Author.

In terms of usage frequency, 31% of respondents reported always using preservation methods, while 69% do not use them consistently. Those who use preservation techniques sometimes account for 44% of respondents, whereas 56% fall into the non-users' category. Rare usage was reported by 20% of respondents, with 80% indicating they rarely use these techniques. Lastly, only 5% of respondents reported never using preservation methods, whereas 95% stated otherwise.

4.2. Effect of Local Agricultural Technologies on Reducing Food Spoilage

The results of the logistic regression model show a reasonable level of model fit (Table 5). The -2 log-likelihood value was 20.142, while the Cox and Snell R-square and Nagelkerke R-Square were. 619 and. 899 respectively. This implies that

the independent variables jointly account for approximately 89% of the variation in the likelihood of food spoilage. While the remaining 11% maybe attributed to other factors not included in the model.

The binary logistic regression analysis in Table 4 reveals that gender significantly influences the adoption of vegetable preservation methods. Specifically, male farmers are 3.518 times more likely to adopt preservation techniques compared to their female counterparts, with a p-value of 0.008, indicating statistical significance at the 1% level. This finding underscores the gender disparities prevalent in agricultural practices, particularly in the context of post-harvest management. Several studies have highlighted that women, despite their pivotal roles in agriculture, often face systemic barriers that hinder their access to resources and decision-making processes. Perelli [49] discusses how intra-household gender dynamics can influence the adaptive capacities

of smallholder farmers, suggesting that women may have less access to information and resources necessary for adopting new technologies. Therefore, to enhance the adoption of preservation techniques, it is crucial to implement gender-sensitive policies

that address these disparities and empower female farmers through targeted training, access to resources, and decision-making platforms.

Table 4. Binary Logistic Regression Results.

Variables	Coefficient	Standard Error	Significance
Gender	-3.518	1.318	.008
Age group			
Below 20	-61.517	15726.795	.997
21 - 30 years	-2.526	1.853	.173
31 - 40 years	-1.224	1.710	.474
41 – 50 years	-21.660	7945.199	.998
Level of education			
No formal education	-23.309	9306.427	.996
Primary education	-.783	2.015	.698
Secondary education	-4.080	1.656	.017
Occupation			
Farmer	16.993	2842.749	1.000
Trader/market vendor	18.536	2756.124	.998
Agricultural extension officer			
transporter	-4.155	1.492	.014
Sun drying	-2.370	.744	.001
Storage in traditional bams	1.181	.331	.000
Use of ash	.887	.459	.054
Use of leaves or plant extracts	-.285	.267	.286
Local refrigeration method	-.674	.597	.042
Constant	3.659	.751	.000

Source: Field survey, 2026 by Author.

Table 5. Model summary.

-2 log likelihood	Cox and Sneil R-Square	Nagelkerke R-Square
20.142	.619	.899

Source: Field survey, 2026 by Author.

The findings of this study provide valuable insights into the determinants of food spoilage in the local context, revealing that several socio demographic factors and traditional preservation methods play a significant role. The negative and statistically

significant relationship between gender and food spoilage ($B = -3.518$, $p = .008$) suggests that being male is associated with a lower likelihood of preventing food spoilage when compared with female respondents. This is potentially due to their passive

role in food processing and household management in many rural African communities. This aligns with the findings of Okechukwu [46], who observed that women in rural Nigeria were more knowledgeable and proactive about food preservation practices, which led to reduced spoilage rates.

The analysis also found that individuals with secondary education experienced significantly less food spoilage ($B = -4.080$, $p = .017$), suggesting that education plays a critical role in knowledge dissemination and the adoption of effective preservation techniques. This finding is consistent with the work of Mdemu [39], who concluded that education improves individuals' understanding of food safety and spoilage prevention techniques, leading to more sustainable post-harvest handling.

In terms of occupation, agricultural extension officers were associated with a significant reduction in food spoilage ($B = -4.155$, $p = .014$), highlighting the value of technical expertise and access to up-to-date agricultural knowledge. Similar findings were reported by Alhassan and Salifu [7], who noted that extension workers play a key role in transferring innovations in food storage and preservation to rural farmers, contributing to a decline in post-harvest losses.

The analysis indicates that various local agricultural technologies significantly influence the adoption of vegetable preservation methods, with differing magnitudes and directions of impact. Specifically, the use of sun drying has a coefficient of -2.370 ($p = 0.001$), indicating a statistically significant negative relationship between sun drying technique and food spoilage, at the 1% level. This suggests that farmers employing sun drying are less likely to experience food spoilage. This is possibly due to the perceived sufficiency of sun drying as a preservation method. This finding aligns with the work of FAO [17], which found sun drying to be one of the most widely adopted and effective preservation techniques in Sub-Saharan Africa. On the other hand, storage in traditional barns showed a positive and significant association with spoilage (B

$= 1.181$, $p < .001$), suggesting that while traditional storage methods are common, they may no longer be effective due to environmental changes, pest infestation, or poor maintenance concerns also noted by Kaminski and Christiansen [26].

The use of ash preservation shows a positive coefficient of 0.887 ($p = 0.054$), significant at the 10% level, suggesting a moderate positive influence. This indicates that ash preservation is an affordable and accessible method for smallholder farmers, potentially facilitating the adoption of other preservation techniques. This resonates with the study of Omojasola [47]. Conversely, the use of leaves or plant extracts yields a coefficient of -0.285 ($p = 0.286$), which is not statistically significant, indicating negligible influence on adoption likelihood.

Finally, interestingly, local refrigeration methods were also associated with a significant reduction in spoilage ($B = -0.674$, $p = .042$), albeit at a smaller effect size. This indicates that even rudimentary or non-electric cooling systems can play a role in reducing spoilage when properly used, which resonates with findings from a study by Kitinoja [35], emphasizing the importance of cold storage options in managing perishables in rural settings.

4.3. Challenges in Implementing Local Agricultural Technologies

As shown in Table 6, the major challenges hindering the adoption of preservation methods include lack of awareness and training (71%), limited storage infrastructure (63%), and climate and weather conditions (54%). High costs (39%) and difficulty accessing materials (16%) were also noted. Moreover, only 40% of respondents reported the availability of government or agricultural extension support, highlighting a significant institutional gap. Financial assistance (89%) and better storage and transportation facilities (61%) were the most requested forms of support to enhance preservation practices.

Table 6. Challenges in Implementing Local Agricultural Technologies.

What are the main challenges you face in using local agricultural technologies for vegetable preservation? (Check all that apply)				
	Not selected		Selected	
	Frequency	Percent	Frequency	Percent
Lack of awareness and training	29	29%	71	71%
High cost of some preservation techniques	61	61%	39	39%
Difficulty in accessing necessary materials	84	84%	16	16%
Limited storage infrastructure	37	37	63	63%
Climate and weather conditions	46	46%	54	54%
Others (specify)	91	91%	9	9%

Source: Field survey, 2026 by Author.

5. Conclusion

In conclusion, this study reveals that food spoilage in Tubah Subdivision is influenced by both socio-demographic and technological factors. Gender, education level, and occupation significantly affect the adoption of preservation methods. Women were found to play a central role in reducing spoilage due to their direct involvement in handling and storing produce. Educational attainment, particularly at the secondary level, improves farmers' ability to adopt effective preservation techniques. Agricultural extension officers were identified as important facilitators for knowledge transfer. Among preservation methods, sun drying emerged as the most widely used and effective, while traditional barn storage showed limitations. Local refrigeration methods offered positive results, though adoption was low, and the use of ash showed potential but requires further validation. These findings highlight the need for an integrated approach that blends traditional practices with modern knowledge and technological innovation to reduce food spoilage. Ultimately, improving education, training, and infrastructure is essential for sustainable vegetable preservation in the Tubah Subdivision.

6. Policy Recommendations

Efforts should be made to strengthen agricultural extension services in Tubah Subdivision by increasing the number of trained officers, enhancing their capacity, and expanding outreach. Regular workshops, on-site demonstrations, and practical training programs would improve farmers' awareness and adoption of preservation methods.

Women should be empowered as key actors in food preservation. This can be achieved through targeted training programs, access to preservation technologies, and opportunities for leadership within farmer cooperatives. Women-focused agricultural support programs should be prioritized to strengthen their role in reducing spoilage.

Educational initiatives should be expanded to raise awareness about preservation techniques. Community-based education campaigns and farmer field schools should be developed, while integrating preservation knowledge into school curricula and adult literacy programs to ensure broader reach.

Traditional storage methods, particularly barns, need to be improved. Upgrading structures with better roofing, ventilation, and pest control mechanisms will reduce spoilage. Such improvements should be supported by government agencies and NGOs.

Proven low-cost preservation technologies such as sun drying and rudimentary refrigeration should be promoted through subsidies, grants, or microcredit schemes. Community drying platforms and solar-powered cold rooms represent practical investments for rural areas.

Abbreviations

GDP	Gross Domestic Product
SDG	Sustainable Development Goals
GMO	Genetically Modified Organisms
SLF	Sustainable Livelihoods Framework
IOT	Internet of Things
NGOs	Non-Governmental Organization
FAO	Food and Agricultural Organization

Author Contributions

Louis Atamja: Conceptualization, Formal Analysis, Methodology, Resources, Supervision

Dvumbighe Mercy Cheah: Data curation, Software, Visualization, Writing – original draft

Nembo Elton Nambuanyi: Validation, Writing – review & editing

Data Availability Statement

Datasets are available on request.

Conflicts of Interest

The authors declare no conflicts of interest.

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